P 16: Plasma Wall Interaction II/Codes and Modeling I

Time: Thursday 14:00–15:30 Location: CHE/0091

Invited Talk P 16.1 Thu 14:00 CHE/0091

Development of a Laser-based Diagnostic for in situ Monitoring of Fuel Retention in ITER and future fusion devices — •Alexander Huber, M. Zlobinski, G. Sergienko, J. Assmann, D. Castano, S. Friese, I. Ivashov, Y. Krasikov, H. Lambertz, Ph. Mertens, K. Mlynczak, M. Schrader, A. Terra, S. Brezinsek, and Ch. Linsmeier — Institut für Energie- und Klimaforschung - Plasmaphysik, Forschungszentrum Jülich GmbH, Jülich

One of the most serious challenges for the operation of ITER and future fusion devices is the control of the inventory of tritium stored in the vessel walls which surround the plasma. For the operation of ITER and of a fusion reactor in general, the determination of the tritium inventory and the knowledge of its spatial distribution is essential. Its control without removal of wall tiles is also of paramount importance. A laser-based T-monitor diagnostic system is under development at Forschungszentrum Jülich (FZJ) to remotely provide information about the tritium content in the deposited layer on the inner divertor tiles of ITER. The T-inventory builds up through the interaction of wall erosion and co-deposition of hydrogen isotopes together with redeposited material. The limitation of the tritium content in the reactor is of course a safety requirement for the operation. The measurement concept is based on laser-induced desorption (LID) and detection of the released gases by Residual Gas Analysis (RGA).

The present contribution summarizes the results of an R&D programme on the LID method carried out at FZJ for the integration of this laser-based tool into ITER and future reactors.

P 16.2 Thu 14:30 CHE/0091

Multi-staged ERO2.0 simulation of material erosion and deposition in recessed ITER mirror assemblies — •Sebastian Rode[1], Juri Romazanov[1], Sebastijan Brezinsek[1], Andreas Kirschner[1], Sven Wiesen[1], Tom Wauters[2], Lucas Moser[2], and Richard Pitts[2] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung, 52425 Jülich, Germany — [2]ITER Organization, 13067 St Paul Lez Durance, France

The Monte-Carlo code ERO2.0 traces impurity particles throughout the volume of fusion devices providing the local erosion and deposition fluxes at plasma-facing components or recessed objects, delivering important information about sputtering or layer growth on those components. In recessed areas, e.g. mirror assemblies in the diagnostic first wall (DFW) of ITER, the code is approaching its limits. The necessary resolution of information on mirrors more than 50 cm away from the LCFS cannot be achieved with standard simulations as only a tiny fraction of impurity test particles and a large fraction of charge exchange hydrogenic neutrals (CXN) reaches this volume. Multi-staged ERO2.0 simulations are employed to overcome this challenge: Impurity particles from a global ERO2.0 simulation with its boundary close to the DFW are collected and subsequently injected into local simulations. The number of test particles representing the fluxes is scaled up, achieving far superior resolution. The results show that the sputtering is largely dominated by high energy CXN, with the patterns indicating a strong influence by the geometry of the assembly. Overall neglible deposition is expected on the mirrors for the full ITER operation time.

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Separation of plasma species fluxes for investigating plasma-surface interactions — •Adrian Heiler[1], Roland Friedl[2], and Ursel Fantz[1,2] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching — [2]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg

Low pressure plasmas are commonly applied for surface treatment processes. To investigate the role of the different plasma species in the plasma-surface interaction, a selective exposure is indispensable. Therefore, the separation of plasma species fluxes from an inductively coupled plasma source (27.12 MHz, 600 W max.) is demonstrated by using magnets and a MgF_2 window. The plasma source is operated in hydrogen at pressures of $4-10$ Pa and is connected to a vacuum chamber in which surfaces can be installed at a sample holder. The impinging fluxes of hydrogen atoms, positive hydrogen ions and UV/VUV photons (up to 15 eV) are quantified by using optical emission spectroscopy, a Langmuir probe and a VUV diagnostic. The VUV diagnostic is based on a photodiode and optical filters for wavelength selection and is calibrated against a VUV spectrometer.

The influence of the UV/VUV photons, hydrogen atoms and positive hydrogen ions on surfaces is exemplarily demonstrated by applying work function measurements of in situ caesiated metal samples. By this, it is shown that each species can affect the surface separately. The impact of the selective exposure is compared to the full plasma-surface interaction by the generation of well-characterized inductively coupled hydrogen plasmas directly in front of the surface.

P 16.4 Thu 15:00 CHE/0091

Hyperfine structure splitting and the Zeeman effect of ^{83}Kr in laser absorption spectroscopy investigated at the linear plasma device PSI-2 — •Marc Sackers[1], Oleksandr Marchuk[1], FNU Dipti[2], Stephan Ertmer[1], Yuri Ralchenko[3], and Arkadi Kreter[1] — [1]Forschungszentrum Jülich GmbH - Institut für Energie- und Klimaforschung - Plasmaphysik, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany — [2]International Atomic Energy Agency, Vienna, Austria — [3]National Institute of Standards and Technology - Atomic Spectroscopy Group, 20899 Gaithersburg, USA

Comparing Ar I and Kr I laser absorption spectra obtained at the linear plasma device PSI-2 indicate an additional line broadening in the case of Kr due to isotopic effects. The magnetic field configurations at PSI-2 provide weak field conditions for even numbered isotopes, i.e., a small perturbation on the energy level splitting. However, concerning ^{83}Kr, the magnetic field strength (B) is de facto intermediate. This condition substantially increases the complexity of the spectra since the energy shift is non-linear in B and the intensities of the magnetic sub-transitions depend on B as well.

The analysis is based on a model by C. G. Darwin of the Zeeman effect at all field strengths [1]. Overall, the experimental investigation at the linear plasma device PSI-2 is limited to laser absorption spectra (20.5 mT to 90 mT) from the Kr I 5s J=2 and J=0 metastable levels using the 760.15 nm and 785.48 nm lines, respectively.

[1] C. G. Darwin, Proc. R. Soc. Lond. A **115**, 1-19 (1927)

P 16.5 Thu 15:15 CHE/0091

Application of Laser Ablation Molecular Isotopic Spectroscopy on a-(^{12}C,^{13}C):H layers in double pulse mode — •Erik Wüst, Rongxing Yi, Christoph Kawan, Timo Dittmar, and Sebastijan Brezinsek — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich

Following the injection of $^{13}CH_4$ into a Hydrogen plasma in Wendelstein 7-X, Laser Ablation Molecular Isotopic Spectroscopy (LAMIS) was utilised to quantify ^{13}C deposition patterns ex-situ on the graphite test divertor. LAMIS was applied in double pulse mode. The first pulse (355 nm, 35 ps, 1.1 J/cm^2) was applied for the production of a laser-induced plasma on the material's surface. A second laser pulse (1064 nm, 35 ps) followed typically 50 ns later. The second laser pulse was focussed into the laser-induced plasma plume of the first pulse in order to improve signal to noise ratio in the spectra and the sensitivity acquired from the emitted light.

In general a good agreement of the ^{13}C content and pattern with DP-LAMIS and the complementarily applied Nuclear Reaction Analysis was found for layers up to a few μm. Deviations were identified for thicker layers, therefore ablation process was investigated regarding the impact of the second laser pulse (2.3 J/cm^2, 50 ns after first pulse) on ablation rate per pulse pair and properties of the plasma plume. Results of these investigations and proposed ways to overcome the challenge of resolving ^{13}C content in thick mixed layers containing carbon and hydrogen are presented.